SINGLE-ASSET RELIABILITY ROI ESTIMATE

Homogenizer HG-1: Maintain, Monitor, or Replace?

A Weibull analysis of failure history and a 10-year lifecycle-cost comparison of four options for the plant's highest-risk process asset, with an after-tax view and a pre-agreed rebuild-or-replace trigger.

SAMPLE — FICTIONAL DAT

CLIENT	Larkspur Valley Foods, Inc. — Plant 2 (cultured dairy)
ASSET	HG-1 homogenizer (register P-02, tier A), feeding all filling lines
REPORT NO.	ROI-2026-005 · Revision 0 · Issued December 11, 2026
DATA BASIS	10 valve and seal set failures (run-to-failure history), major-failure and overhaul records, OEM quotes, plant finance FY2026 standards
METHODS	Weibull analysis (IEC 61649:2008), age-replacement optimization, life cycle costing (IEC 60300-3-3:2017), NPV / IRR / EAC, after-tax with MACRS 7-year
RELATED WORK	CA-2026-003 ranks HG-1 the highest-risk process asset at about $100K/yr; this report reconciles to that baseline

Demonstration document. Sample report. All company names, people, data, and financial figures are fictional and shown for demonstration only. The structure, methods, and level of detail match Apex Reliability Engineering client deliverables.

Executive Summary

Decision brief for the Plant Manager and Plant Controller. Sections 1–6 contain the supporting detail.

BOTTOM LINE

HG-1's valve and seal failures are **wear-out failures (β = 3.2)**, so replacing the set on a schedule beats running it to failure. Doing that in sanitation windows, with oil and vibration routes, needs **no capital** and is worth **$300K** over 10 years. Adding online monitoring raises that to **$318K** for $28K of CAPEX, and gives the plant early warning on the $150K failure mode. **Replacing the homogenizer is not justified today.** A pre-agreed trigger (Section 5) says when it would be.

COST OF UNRELIABILITY TODAY	WEIBULL SHAPE (B)	RECOMMENDED (O2) NPV	O2 PAYBACK	REPLACE (O3) VS. O2
$99.1K/yr	**3.24**	**$318K**	**6.0 mo**	**−$141K**
Reconciles to CA-2026-003 within 1%	Wear-out; η = 3,222 h	Pre-tax, 10 yr; $236K after tax	On $28K monitoring CAPEX	NPV gap; O3 negative in conservative case

DECISIONS REQUESTED

1. **Implement O1 now:** planned valve and seal set changes every 1,500 operating hours, plus oil and vibration routes. No CAPEX; $2,400/yr in route costs.
2. **Approve $28K CAPEX for online monitoring** (O2) on crankcase bearings and seal leakage, at $3,000/yr.
3. **Adopt the rebuild-or-replace trigger** in Section 5, so a replacement decision can be made in days if a major failure occurs.

OPTIONS COMPARED (10-YEAR, PRE-TAX, 10%)

OPTION	PV OF COST	NPV VS. O0	EAC
O0 · Status quo	$713K	—	$116K
O1 · Optimized PM	$413K	$300K	$67K
O2 · Optimized PM + online monitoring	**$395K**	**$318K**	**$64K**
O3 · Replace with new homogenizer	$536K	$176K	$87K

EAC: equivalent annual cost, the PV of cost spread evenly over 10 years. Lowest is best.

THE HONEST READ ON MONITORING

Most of the value comes from O1, which needs no capital. Monitoring adds $18K of expected NPV on top of O1, and it loses to O1 in the conservative case. It is recommended as low-cost insurance on the $150K failure mode and as the data feed for the replace trigger, not as the main source of return.

SAMPLE — FICTIONAL DATA

1 Asset and Baseline

HG-1 sits upstream of every filling line. When it stops, the plant stops, which is why a $4K seal set can cost more than $33K when it fails in production.

TABLE 1.1 — ASSET PROFILE

ATTRIBUTE	DETAIL
Function	Homogenizes cultured base before filling; single unit, no bypass
Duty	About 6,000 operating h/yr; one full sanitation per day
Criticality	Tier A (P-02): production 5, repair 5
Downtime cost	$6,500/h (all filling lines idle, net of recovery)
Age and support	14 years; OEM parts supported; overhauls due in years 3 and 8 of this horizon

TABLE 1.2 — COST OF UNRELIABILITY TODAY (STATUS QUO)

FAILURE TYPE	PER YR	$ / FAILURE	$ / YR
Valve and seal set, run to failure	2.08	$33,268	$69,131
Major mechanical failure	0.20	$150,000	$30,000
Total			**$99,131**

Valve and seal failure rate = 6,000 h ÷ Weibull mean life of 2,887 h. Cost per unplanned failure = parts $3,800 + labor + 4 h downtime + $3,000 product loss.

WHY THE SAME PART COSTS EIGHT TIMES MORE WHEN IT FAILS

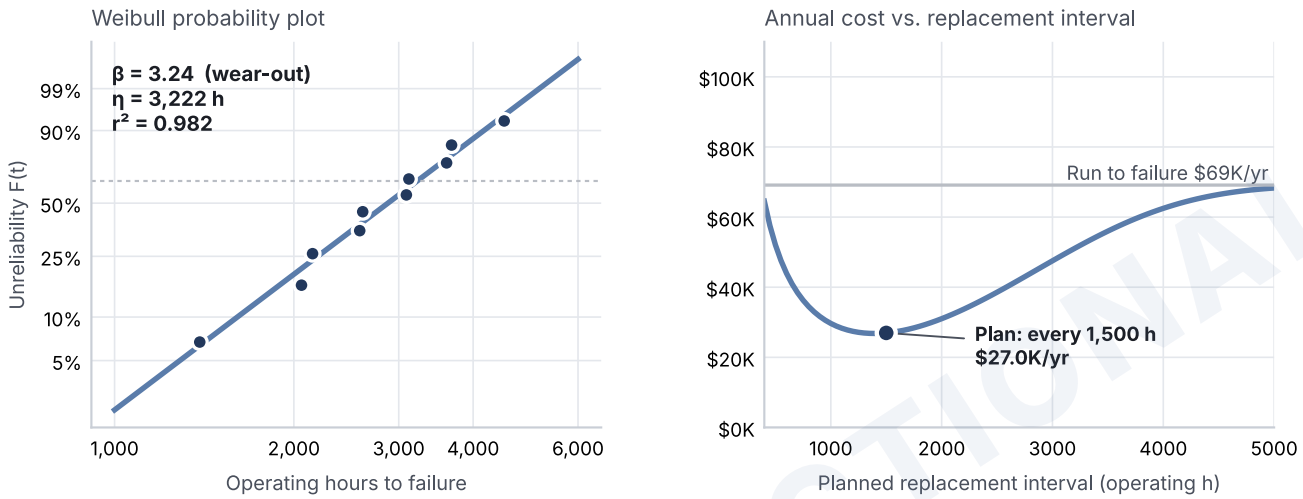
A planned set change in a sanitation window costs $4,268: parts and labor, with no lost production. The same change after an in-production failure costs $33,268. That 8:1 ratio, combined with wear-out behavior, is what makes planned replacement pay.

SAMPLE — FICTIONAL D

2 Failure Data Analysis

If failures were random (β ≈ 1), replacing parts early would waste money. They are not random: the risk of failure rises steeply with operating hours.

FIGURE 2.1 — WEIBULL FIT AND COST-OPTIMAL REPLACEMENT INTERVAL



Left: median-rank regression on 10 run-to-failure intervals. Right: expected annual cost of the valve and seal set by planned interval (age-replacement model), against run-to-failure cost.

TABLE 2.1 — WEIBULL RESULTS

PARAMETER	VALUE	MEANING
Shape β	3.24	Above 1 means wear-out; above 3 means strongly age-related
Scale η	3,222 h	63.2% of sets fail by this age
Mean life	2,887 h	About 5.8 months of operation
Fit (r^2)	0.982	Good linear fit on the Weibull plot

TABLE 2.2 — REPLACEMENT INTERVAL CHOICE

INTERVAL	RELIABILITY AT CHANGE	ANNUAL COST
Run to failure	—	$69,131
Mathematical optimum, 1,400 h	93%	$26,808
Recommended, 1,500 h	**92%**	**$26,967**

1,500 h lines up with a quarterly sanitation window and costs $158/yr more than the optimum, because the cost curve is flat near its minimum.

SAMPLE — FICTIONAL D

3 Options Evaluated

Four mutually exclusive options, each costed over the same 10-year horizon so they can be compared directly.

TABLE 3.1 — OPTIONS AND THEIR EFFECTS

OPTION	WHAT IT INCLUDES	CAPITAL	ANNUAL OPERATING COST
O0 · Status quo	Run seals and valves to failure; time-based lubrication; overhauls in years 3 and 8	$0	$99,131
O1 · Optimized PM	Planned valve and seal set change every 1,500 h in sanitation windows; quarterly oil analysis and monthly vibration route	$0	$50,367
O2 · Optimized PM + online monitoring	O1 plus wireless vibration and temperature on crankcase bearings and seal-leak detection, with alarms to the CMMS	$28,000	$42,867
O3 · Replace with new homogenizer	New unit with ceramic plungers and a higher-efficiency drive, plus O2 practices; old unit sold	$520,000	$6,732

Annual operating cost = task costs + expected failure cost + energy change, excluding overhauls. O3's figure is low because the new unit's energy savings ($18,000/yr) offset most of its failure and task costs.

TABLE 3.2 — KEY ASSUMPTIONS

ASSUMPTION	VALUE AND BASIS
Major-failure risk reduction	O1 30% (early detection by oil and vibration routes); O2 65% (continuous monitoring); O3 85% (new unit)
Valve and seal failures, O3	45% lower than O1/O2 (ceramic plungers, OEM data). ESTIMATE
Overhauls, existing unit	$85,000 in years 3 and 8 (OEM quote); none for O3 within the horizon
O3 capital	$520,000 installed, including removal; old unit sold for $25,000
Finance	10% pre-tax hurdle rate; 25% tax rate; MACRS 7-year depreciation; bonus depreciation excluded (Controller to confirm eligibility)

SAMPLE — FICTIONAL D

Sample report. All company names, people, data, and financial figures are fictional and shown for demonstration only.

4 Financial Analysis

On lifecycle cost, O2 is lowest, O1 is a close second with no capital, and replacement costs more than either over 10 years.

FIGURE 4.1 — 10-YEAR PRESENT VALUE OF COST BY OPTION

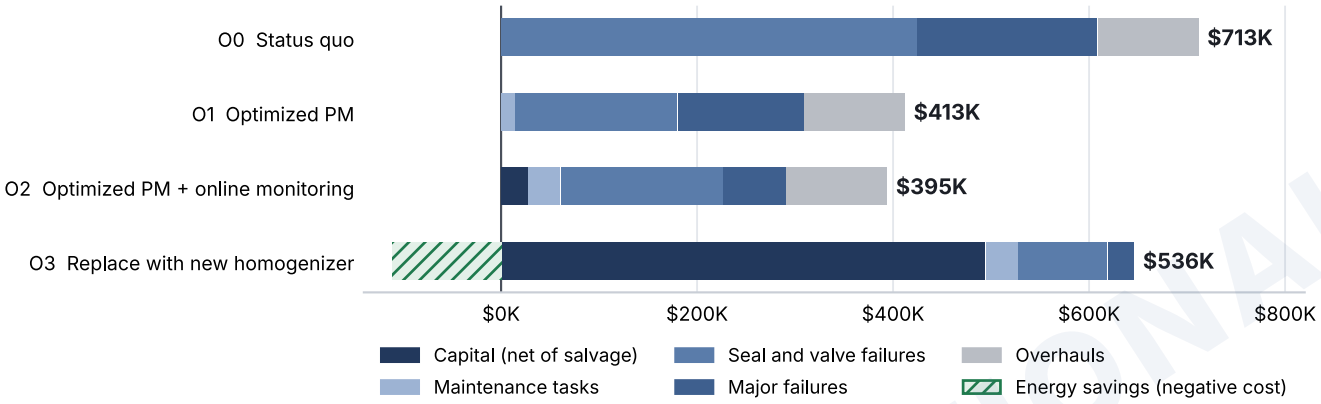


TABLE 4.1 — INCREMENTAL RETURNS AGAINST THE STATUS QUO

	O1	O2	O3
Year-0 investment	$0	$28,000	$495,000
Year-1 savings vs. O0	$48,764	$56,264	$92,399
NPV, pre-tax	**$299,636**	**$317,720**	**$176,269**
NPV, after tax	$224,727	$236,340	$102,241
IRR	n/a	> 100%	18%
Payback	Immediate	6.0 mo	53.2 mo
Profitability index (PV ÷ investment)	n/a	12.3×	1.4×

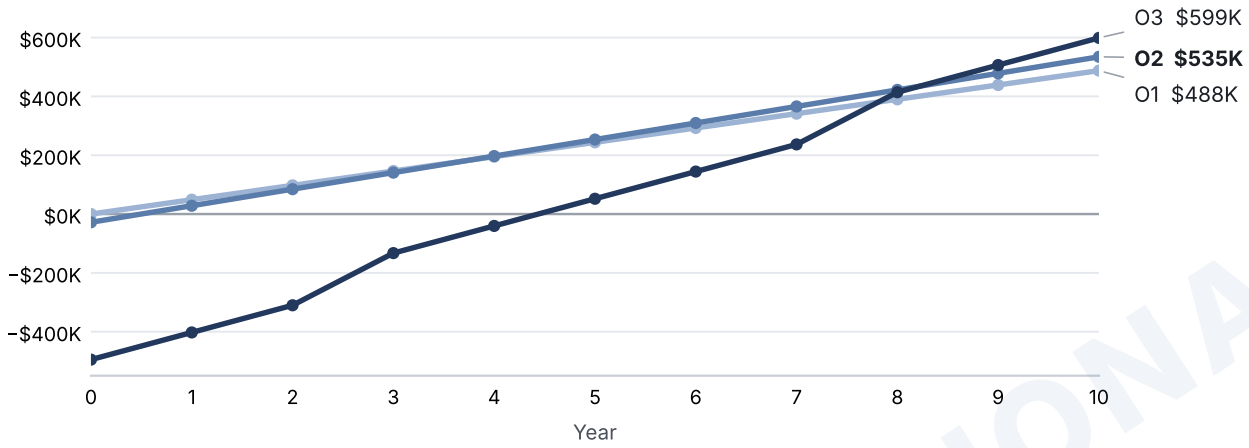
Choosing between O1 and O2: they are mutually exclusive, so the deciding figure is the increment. O2 over O1 is $18,084 of NPV (24% IRR) on $28,000. That is positive but modest. O1 has no investment, so IRR and payback do not apply to it.

SAMPLE — FICTIONAL D

4 Financial Analysis (continued)

How the options behave over time and under pessimistic assumptions.

FIGURE 4.2 — CUMULATIVE SAVINGS AGAINST THE STATUS QUO (UNDISCOUNTED)



O3 starts $495K down, crosses zero in year 5, and ends highest on undiscounted savings. Its savings arrive late, though, so on a discounted basis (Table 4.1) it trails O2 by $141K. The jumps in years 3 and 8 are the overhauls O3 avoids.

TABLE 4.2 — NPV BY SCENARIO (PRE-TAX)

SCENARIO	O1	O2	O3
Conservative	$136K	$121K	−$79K
Expected	**$300K**	**$318K**	**$176K**
High impact	$378K	$412K	$299K

Conservative: 60% of rated benefit, downtime cost −20%. **High impact:** downtime cost +25%. O3 is the only option that goes negative.

TABLE 4.3 — STRESS TESTS ON O2

STRESS APPLIED	NPV
Base case (expected)	**$317,720**
Only half of the rated benefit realized	$128,270
Downtime cost rate −30%	$204,050
Monitoring CAPEX doubled	$289,720
All of the above	$43,435

ACCOUNTING TREATMENT

O1 is entirely OPEX. O2's monitoring hardware ($28,000) is CAPEX, depreciated over 7 years under MACRS. O3 is CAPEX of $520,000, with a $25,000 disposal proceed; any gain or loss on disposal is for Controller review. After-tax NPVs include depreciation tax shields at 25% and exclude bonus depreciation.

SAMPLE — FICTIONAL D

5 Recommendation and Replace Trigger

Maintain and monitor now. Decide in advance what would justify replacement, so that a major failure leads to a quick, prepared decision rather than an emergency purchase.

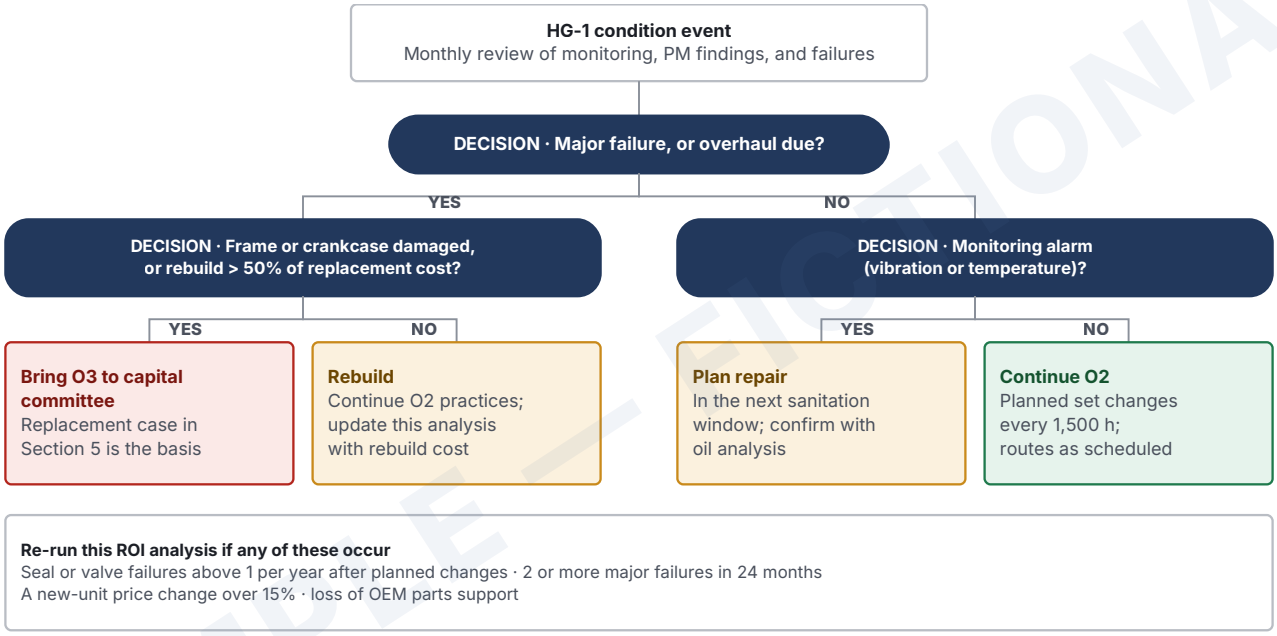
RECOMMENDATION

Adopt **O2**: implement O1's planned changes and routes immediately, and add online monitoring for $28,000. Expected NPV $317,720 pre-tax, $236,340 after tax.

WHY NOT REPLACE NOW

O3 trails O2 by $141,451 of NPV and goes negative in the conservative case. Its case gets stronger if a major failure damages the frame or if rebuild costs climb, and the trigger below covers both.

FIGURE 5.1 — DECISION TREE: REBUILD OR REPLACE HG-1



SAMPLE — FICTIONAL D

Larkspur Valley Foods, Inc. — Plant 2 · Confidential, client internal · Prepared by Apex Reliability Engineering
Sample report. All company names, people, data, and financial figures are fictional and shown for demonstration only.

6 Implementation, Verification, and Limitations

What gets done, how success is measured, and what the analysis cannot see.

TABLE 6.1 — IMPLEMENTATION

WINDOW	WORK	OWNER
Weeks 0–4	Create the 1,500 h set-change PM on run-hour meter; stock two seal and valve sets; add oil and vibration routes	Planner · Reliability
Weeks 4–10	Install wireless sensors on crankcase bearings and seal-leak detection; set alarm limits; route alarms to the CMMS	Controls · Reliability
Month 12	Compare realized failures and costs with the model; refit the Weibull with new data	Reliability · Controller

TABLE 6.2 — VERIFICATION MEASURES

MEASURE	TARGET
Unplanned valve and seal failures	≤ 1 per year (from 2.1)
Planned set changes on schedule	≥ 95% within ±10% of 1,500 h
HG-1 unplanned downtime	≥ 50% reduction against the trailing 12 months
Monitoring alarms acted on	100% assessed within 24 h; outcome logged

TABLE 6.3 — LIMITATIONS

GAP	EFFECT
Weibull fit on 10 failures	Adequate for a shape estimate, but β has a wide confidence band. The cost curve is flat near the optimum, so the interval choice is robust to it.
Major-failure rate (0.2/yr) from limited history	Drives the monitoring increment. Tested in the scenarios and stress tests.
Risk-reduction factors are estimates ESTIMATE	Checked at the month-12 review; the conservative case assumes 60% of rated benefit
O3 performance from OEM claims	Not field-verified at this plant. One reason replacement waits for the trigger.

SAMPLE — FICTIONAL D

A Data, References, and Approval

TABLE A.1 — VALVE AND SEAL SET FAILURE DATA (OPERATING HOURS TO FAILURE)

RANK	1	2	3	4	5	6	7	8	9	10
Hours	1,390	2,060	2,150	2,580	2,610	3,090	3,120	3,610	3,680	4,510
Median rank	0.067	0.163	0.260	0.356	0.452	0.548	0.644	0.740	0.837	0.933

Median ranks by Bernard's approximation, (i − 0.3) / (n + 0.4). All intervals are complete failures with no suspensions. Age-replacement cost rate $C(T) = [Cp \cdot R(T) + Cf \cdot (1 - R(T))] \div \int_0^T R(t)\,dt$.

TABLE A.2 — STANDARDS AND REFERENCES

REFERENCE	TITLE AND USE
IEC 61649:2008	Weibull analysis. Parameter estimation and goodness of fit.
IEC 60300-3-3:2017	Dependability management — Part 3-3: Application guide — Life cycle costing. LCC structure and option comparison.
ISO 55001:2024	Asset management — Asset management system — Requirements. Lifecycle decision-making context.
CA-2026-003	Asset Criticality Analysis, Plant 2. Tier A ranking and baseline risk for HG-1.

REVIEW AND APPROVAL

Prepared by
Lead Reliability Engineer, Apex Reliability Engineering
Signature _____ Date _____

Financials validated by
Plant Controller
Signature _____ Date _____

Approved by
Plant Manager
Signature _____ Date _____

SAMPLE — FICTIONAL D